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Surficial Geology of the Norway 7.5-minute Quadrangle, Oxford and Cumberland Counties, Maine

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INTRODUCTION

This report describes the surficial geology and Quaternary history of the Norway 7.5-minute quadrangle in southwestern Maine. Surficial earth materials include unconsolidated sediments (sand, gravel, etc.) of glacial and nonglacial origin. Most of these deposits formed during and after the latest episode of glaciation in Maine, within the last 25,000 years. Surficial sediments cover the bedrock over most of the quadrangle and are subject to many uses and environmental considerations. These include sand and gravel extraction, development and protection of ground-water supplies, siting of waste disposal facilities, and agriculture.

The field work for this study was carried out in 1999 for the STATEMAP cooperative between the Maine Geological Survey and the U. S. Geological Survey (USGS). Two maps are associated with this report. The *geologic map* (Thompson, 2000) shows the distribution of sedimentary units, and indicates their age, composition, and known or inferred origin. It also includes information on the geologic history of the quadrangle, such as features indicating the flow direction of glacial ice. This map provides the basis for the discussion of glacial and postglacial history presented here.

The *materials map* (Locke and Thompson, 2000) shows specific data used to help construct the geologic map. These data include observations from gravel pits, shovel and auger holes, construction sites, and natural exposures along stream banks. The materials map also shows boring logs. Sand and gravel aquifer studies by the USGS provided additional data on the type and thickness of surficial sediments in the quadrangle (Morrissey, 1983; Prescott, 1967, 1968).

Geographic Setting

The Norway quadrangle is located on the approximate border between the White Mountain foothills (a.k.a. Oxford Hills)

and the coastal lowland of southwestern Maine. The map area extends in latitude from 44°07'30" to 44°15'00" N, and in longitude from 70°30'00" to 70°37'30" W. It encompasses parts of the towns of Norway, Paris, Oxford, and Otisfield in Oxford County, and Harrison in Cumberland County. The neighboring cities of Norway and South Paris constitute a major population center in the quadrangle.

The principal streams are the Little Androscoggin River in the east, Greenley Brook in the south-central, and the Crooked River in the southwest part of the Norway quadrangle. Penneesseewassee Lake and several ponds occur in the map area. The topography is hilly across much of the quadrangle. Elevations range from about 305 ft (93 m) above sea level (where the Little Androscoggin River crosses its eastern border) to 990 ft (302 m) on the summit of Jim Hill near the western edge of the map.

Bedrock Geology

Quaternary sediments cover the bedrock over much of the Norway quadrangle, but outcrops are very common on the hills. Most of the map area is underlain by granite of Carboniferous age, which is part of an extensive granite body called the Sebago pluton. Metasediments of the Silurian Patch Mountain Formation occur in the northern part of the quadrangle (Osberg and others, 1985). Veins of granite pegmatite are found throughout the area.

PREVIOUS WORK

Stone (1899, p. 223-226, 476) described the glacial drainage system in the Little Androscoggin Valley. He noted that the outwash in this valley becomes finer-grained south of Norway and is underlain by clay deposits. Stone also speculated that after deglaciation an arm of the sea extended up the valley as far as

Oxford or Norway. Leavitt and Perkins (1935) briefly described the glacial geology of the Little Androscoggin Valley, but these authors were inconclusive about the former extent of the sea.

Prescott (1967, 1968) compiled well and test hole data, and carried out preliminary surficial and gravel aquifer mapping in the Norway area. He also prepared a map of surficial deposits in the Little Androscoggin Valley, which was included in an aquifer study by Morrissey (1983).

Neil and Locke (1998) compiled a detailed aquifer map of the Norway quadrangle as part of the Maine Geological Survey's Significant Sand and Gravel Aquifer Project. The U. S. Department of Agriculture's soil survey of Oxford County (Wilkinson, 1995) provided useful materials information for several sites that the present author did not visit in the field.

DESCRIPTION OF GEOLOGIC MAP UNITS

The surficial deposits represented on the geologic map have been classified on the basis of their age and origin. Map units are designated by letter symbols, such as "Pt". The first letter indicates the age of the unit:

- "P"-Pleistocene (Ice Age);
- "H"-Holocene (postglacial, i.e. formed during the last 10,000 years);
- "Q"-Quaternary (encompasses both the Pleistocene and Holocene epochs)

The Quaternary age is assigned to units which overlap the Pleistocene-Holocene boundary, or whose ages are uncertain. The other letters in the map symbol indicate the origin and/or assigned name of the unit, e.g. "t" for glacial till and "golb" for glacial outwash deposited in the Lombard Brook valley. Surficial map units in the Norway quadrangle are described below, starting with the older deposits that formed in contact with glacial ice.

Till (unit Pt)

Till is a glacially deposited sediment consisting of a more-or-less random mixture of sand, silt, and gravel-size rock debris. In southern Maine it typically includes numerous boulders. Till blankets much of the upland portions of the quadrangle, where it is the principal surficial material; and it presumably underlies younger deposits in the valleys. Some of the till in Maine probably was derived from glacial erosion of older surficial sediments (either glacial or non-glacial), while the remainder was freshly eroded from nearby bedrock sources during the latest glaciation.

Pit exposures in the Norway quadrangle have revealed up to 20 ft (6 m) of till, and well logs indicate the thickness locally is as much as 160 ft (49 m) (Locke and Thompson, 2000). Till is thin on the tops of many hills, where bedrock is likely to be exposed. A ruled line pattern on the geologic map shows areas where bedrock outcrops are common and/or the till thickness is inferred to be less than 10 ft (3 m).

Till is, by definition, a poorly sorted sediment (diamicton) in which there is a very wide range of rock and mineral particle sizes. However, the texture and structure of individual till deposits vary depending on their source and how they were formed. In the Norway quadrangle, till may include a small percentage of clay, but it has a dominantly sandy or silty-sandy matrix as a consequence of having been eroded from coarse-grained bedrock. Till has little or no obvious stratification in some places. Elsewhere it is crudely stratified, with discontinuous lenses and laminae of silt, sand, and gravel resulting from sorting by meltwater during deposition.

Stones are abundant in this unit, and boulders scattered across the ground surface often indicate the presence of till. Till stones in the quadrangle chiefly consist of coarse-grained igneous and metamorphic rocks, especially granitic rocks derived from local bedrock sources. Most till stones are more-or-less angular, and some have smooth, flat, striated surfaces due to subglacial abrasion. These faceted surfaces are best developed on dense, fine-grained rocks such as basalt (basalt occurs as dikes cutting other rock types in southwestern Maine).

Varieties of till formed beneath a glacial ice sheet include lodgement and basal melt-out tills. Lodgement till was deposited under great pressure beneath the ice sheet. It may be very compact and difficult to excavate ("hardpan"), with a platy structure (fissility) evident in the upper, weathered zone (see photo on geologic map). Basal melt-out till is difficult to identify with certainty, but typically shows a crude stratification inherited from debris bands in the lower part of the glacier. Ablation till formed during the melting of the ice and tends to be loose-textured and stony, with numerous lenses of washed sediment. More than one of these till varieties may occur at a single locality. For example, a thin veneer of stony ablation till commonly overlies lodgement till.

Field evidence in southern Maine and elsewhere in New England (e.g. Koteff and Pessl, 1985; Thompson and Borns, 1985; Weddle and others, 1989), suggests that till deposits of two glaciations are present in the region. The "upper till" is clearly the product of the most recent, late Wisconsinan glaciation, which covered southern Maine between about 25,000 and 13,000 years ago. Exposures of upper till can be seen in many shallow pits, road cuts, and temporary excavations. It is not weathered (except in the near-surface zone of modern soil formation) and is usually light olive-gray in color. Lodgement and ablation facies of the upper till have been recognized in the Norway quadrangle (see materials map by Locke and Thompson, 2000).

The "lower till" consists of compact, silty-sandy lodgement deposits. In southwestern Maine, as in other parts of New England, it is likely to be found in drumlins and other smooth, glacially streamlined hills where a considerable thickness of till has accumulated. These thick deposits often occur as "ramps" on the gentle northwest-facing slopes of hills, while bedrock is exposed on the steeper, glacially plucked southeast slopes. The lower till is distinguished by its thick weathering profile, which

may extend to a depth of 10 ft (3 m) or more. Within this weathered zone, the till is oxidized and has an olive-gray to dark olive-gray or dark grayish-brown color. Dark-brown iron/manganese oxide staining coats the surfaces of stones and joints (Thompson, 1986). Probable equivalents of this till in southern New England are believed to have been deposited during an earlier glaciation in Illinoian time, prior to 130,000 years ago (Weddle and others, 1989).

The author has not seen any exposures of lower till in the Norway quadrangle, perhaps because borrow pits are rare in this hard-to-excavate sediment. The considerable till thickness in some of the streamlined hills in the quadrangle suggests that the lower till may be present at depth. An extremely dense lodgement till occurs beneath glacial fan gravel and a late Wisconsinan lodgement till in the Norway town pit, located in the adjacent West Paris quadrangle (Thompson and others, 2000). The stratigraphic position and presence of rotten stones in this buried unit suggest that it is probably equivalent to the lower till seen elsewhere.

End Moraines (unit Pem)

End moraines are ridges of sediment deposited at the margins of glaciers. They may form in many different ways, but generally are sediment accumulations derived from the adjacent glacial ice (or shaped by glacial processes at the ice margin). Moraine ridges located above the zone of late-glacial marine submergence in southwestern Maine commonly are strewn with boulders on the surface. Their interiors are seldom well exposed, but surface indications and shallow pits suggest that most end moraines are comprised largely of till with locally abundant lenses of sand and gravel.

True end moraines (which are useful markers of ice-margin positions) may be difficult to distinguish from areas of hummocky moraine or ribbed moraine (q.v.), both of which occur in the Norway quadrangle. Till ridges that are thought to be end moraines have been found in two areas in the Norway quadrangle. A single large moraine is located in the Greenley Brook valley in the southeast part of the map area. This moraine has a total relief of about 80 ft (24 m) and is perpendicular to the valley axis. Many large boulders litter its surface, including a very peculiar granite boulder cut by a basalt dike, resembling a giant stone sandwich (see photo on geologic map). The moraine may have been deposited because the glacier margin was temporarily anchored where the valley is constricted by large bedrock outcrops such as those seen on the proximal side of the moraine and directly across Greenley Brook to the northeast.

Two short end moraines occur on Route 117 in the west-central part of the quadrangle. Like the moraine described above, they are bouldery cross-valley ridges. The east-west trends of these moraines are in accord with nearby striations indicating glacial ice flow toward 184°.

The end moraines occur in topographically low areas. This is probably the result of meltwater and debris-flow processes fo-

cusings the deposition of glacial sediments in front of ice tongues as the ice sheet retreated northward from the valleys. The thick sediment accumulations in the moraines suggest the presence of active ice during deglaciation of the Norway quadrangle.

Ribbed moraine (unit Prm)

Ribbed moraine (Prm) consists of groups of till ridges located in the bottoms of valleys that are more-or-less parallel to glacial flow directions (Holland, 1986). There has been much debate about where and how these ridges formed relative to the glacier margin (Davis, *in* Thompson and others, 1995, p. 46-48). In the Norway quadrangle, there is a cluster of ribbed moraine deposits on the east side of the Crooked River. It is possible that the moraine ridges in this area are true end moraines.

Hummocky moraine (unit Phm)

Areas of hummocky moraine (Phm) have been mapped at the south end of Pennessewassee Lake in Norway and southwest of Horse Hill in Oxford. These deposits are distinguished in the field by their knobby topography, and boulders usually are abundant. The scarcity of bedrock outcrops, together with the topographic relief, suggests that the thickness of this unit may be tens of feet. The internal portion of the hummocky moraine is not exposed, but sections elsewhere in southwestern Maine show that it usually consists of diamicton (till) with variable amounts of sand and gravel.

Hummocky moraine is concentrated in lowlands, but occurs at higher elevations than nearby waterlaid glacial deposits consisting of sand and gravel. As proposed by Holland (1986), the location, composition, and topography of unit Phm suggest that it formed during the melting of stagnant debris-rich ice in a late stage of deglaciation. The location of Phm deposits on the lower southwest slope of Horse Hill, and their association with meltwater channels, support Holland's interpretation.

Esker deposits (unit Pge)

One of the most significant glacial features in the Norway quadrangle is an esker (Pge) that extends from the north edge of the map area southward along the Little Androscoggin River valley. This segmented ridge of sand and gravel was deposited by meltwater streams flowing south in a tunnel at the bottom of the last glacial ice sheet. In places it is bordered by depressions (kettles) left when masses of glacial ice melted. The ridge is part of a branching esker system that can be traced from northwest of the Mahoosuc Range discontinuously south for many miles to a large glaciomarine delta complex in New Gloucester. Whether meltwater flowed simultaneously through this entire tunnel network is debatable, but it is likely that the esker segments formed

progressively from south to north as the tunnel became clogged with sediment during deglaciation.

The exposed segments of the esker are up to 50 ft (15 m) high, but in many places it is more or less buried by the adjacent younger outwash deposits. Pits along the esker show material mostly ranging from sand to pebble-cobble gravel, with boulders in a few places. The esker system is very important to the Norway-South Paris urban area, both as a municipal aquifer and a source of sand and gravel. The materials map (Locke and Thompson, 2000) shows numerous borrow pits along its length. Parts of the esker have been mined out, resulting in a leveling of the original ridge topography.

Glaciomarine delta (unit Pmdo)

A sandy outwash plain follows the Little Androscoggin Valley south from the town of Norway and also extends into the adjacent Greenley Brook valley. The flat upper surface of this plain rises northward from about 355 ft (108 m) near the south edge of the quadrangle to at least 395 ft (120 m) in Norway. Surface exposures are usually shallow, but data from test borings (Morrissey, 1983; Neil and Locke, 1998) indicate that unit Pmdo locally is as much as 110 ft (34 m) thick. It consists mostly of sand or pebbly sand, though fine gravel occurs in places.

The ocean immediately submerged the lowlands of southern Maine during retreat of the last ice sheet. Glacial meltwater washed sediments into the sea, forming large flat-topped deposits of sand and gravel called deltas. The upper limit of this marine submergence has been determined by measuring the elevations of contacts between topset and foreset beds in the deltas (Thompson and others, 1989). These contacts are often observed where the deltas have been excavated in borrow pits. Extrapolation of marine-limit contours based on deltas in southwestern Maine suggests a late-glacial sea level of about 370-380 ft (113-116 m; highest to the northwest) in the Little Androscoggin Valley between Oxford and South Paris. The tops of deltas in this area would be slightly higher, depending on the thickness of fluvial sediments that have accumulated on them. Thus, at least the higher part of the Pmdo sand plain (around Norway) probably is an unmodified delta built into the late-glacial sea. The lower southern portion in Oxford may have been eroded during offlap of the ocean.

In the Oxford portion of the Little Androscoggin Valley, unit Pmdo overlies silt and clay of probable glaciomarine origin (Presumpscot Formation). The clay is totally buried by unit Pmdo in the Norway quadrangle, but occurs locally at the surface farther down the valley in the adjacent Oxford quadrangle. It is presumed to be a marine clay because of its low elevation (below the marine limit) and proximity to extensive Presumpscot Formation deposits southeast of the quadrangle. Test borings showing gradational contacts between the clay and overlying sand plain (Morrissey, 1983) support the interpretation that unit Pmdo is a marine delta that prograded into the Little Androscoggin Valley.

Little Androscoggin River outwash (unit Pgol)

Based on higher elevations and the absence of marine clay deposits, the northern part of the Little Androscoggin Valley is inferred to lie above the marine limit. This part of the valley contains abundant sand and gravel (Pgol) deposited by meltwater streams in front of the northward-retreating glacier margin. The Pgol outwash merges with the marine delta (Pmdo) in the vicinity of South Paris, and the contact between these units is approximately located on the geologic map.

Subsurface data indicate that the Pgol deposits reach thicknesses of at least 60 ft (18 m). They mostly consist of sand, pebbly sand, and pebble gravel. Some of this material was deposited in contact with remnant masses of glacial ice, and kettles (depressions) occur where the ice blocks subsequently melted. A large kettle can be seen on the east side of Main Street in the town of South Paris. Several borrow pits have been worked in the Pgol deposits.

Lombard Brook outwash (unit Pgolb)

A small area of sand deposits (Pgolb) was mapped along Lombard Brook in the west-central part of the quadrangle. These deposits were laid down by glacial meltwater streams issuing from the ice margin when it stood a short distance to the north. The ice margin positions are marked by moraine ridges along Route 117 (see map) and associated channels carved by meltwater flowing south into the Lombard valley.

Crooked River Outwash (unit Pgoc)

The Crooked River valley contains extensive deposits of outwash sand and gravel (Pgoc). These deposits underlie a discontinuous flat surface at elevations higher than the modern river flood plain. Sediments comprising unit Pgoc are usually well-rounded gravel or gravelly sand at the surface, but finer sand may occur at depth. The thickness of the outwash exceeds 20 ft (6 m) in places, but its maximum thickness is not known. Well logs indicate depths-to-bedrock of up to 50 ft (15 m) (Locke and Thompson, 2000), but some of this thickness may be till underlying the sand and gravel.

Excellent exposures of unit Pgoc were seen in borrow pits south of Twin Bridges on both sides of the Crooked River valley. Cross bedding at these localities clearly indicates glacial stream flow down the valley. The pit closest to Twin Bridges (west side of valley) showed a sequence of several stacked sets of fluvial cross beds (see photos on geologic map). Pits on the east side of the valley show the contact between outwash sand and gravel and underlying till along the valley wall.

Lacustrine Deposits (unit Ql)

A very small deposit of glaciolacustrine(?) sediment (Ql) was mapped adjacent to the causeway across the south end of

Pennesseewassee Lake. Three feet of silt and sand was encountered in an auger hole at this locality. Prescott (1967) reported a test boring log from the same unit, indicating 5 ft of fill overlying 25 ft of clay and fine sand, but for some reason the latter material was interpreted as till. If the fine-grained sediments are natural and waterlaid, they would have been deposited in a lake at a higher level than the modern lake. However, no other evidence for such a lake has been found, so this interpretation is tentative.

Eolian deposits (unit Qe)

Small accumulations of eolian (windblown) sand were mapped on the east side of the Crooked River valley in Norway. These deposits (Qe) resulted from wind erosion of outwash sand in the Crooked valley. They probably formed in late-glacial time, when vegetation cover was sparse. The prevailing winds blew from the west, as they do today, and carried sand up onto the eastern walls of valleys in Maine (McKeon, 1989). The presence or absence of these deposits usually depends on whether the valleys contained sandy glacial sediments that were not too wet or compacted to be eroded by the wind.

Eolian sand is almost certainly more extensive than shown on the geologic map. Thin patchy deposits are easily overlooked in wooded areas, or may not be obvious where water-laid sand deposits are also present. For example, a recently opened borrow pit near the east edge of the Crooked River outwash plain exposed eolian sand dunes overlying the outwash sand. This pit is located about 0.7 mile from the southern border of the quadrangle.

Stream terrace (unit Qst)

In the process of cutting down to its present level, the Crooked River has eroded the glacial outwash deposits. This has resulted in the formation of at least one prominent terrace (Qst) near the west edge of the quadrangle. The terrace may be inundated to some extent by major floods, but it appears to be slightly higher than the modern flood plain.

Wetland deposits (unit Hw)

Unit Hw consists of fine-grained and organic-rich sediments deposited in low, flat, poorly drained areas. In the Norway quadrangle this unit occurs mostly in valleys and upland basins. The boundaries of unit Hw were mapped primarily from aerial photographs. These boundaries are approximately located and should not be used rigorously for land-use zoning. There is little information on the thickness of wetland deposits in the quadrangle. A report by Cameron and others (1984) describing peat deposits in southwestern Maine notes that they usually average less than 20 ft (6 m) thick.

Stream alluvium (unit Ha)

Unit Ha consists of alluvial sand, gravel, silt, and organic material deposited by modern streams. In the Norway quadrangle, these deposits occur mostly along parts of the Crooked River, Little Androscoggin River, and Greenley Brook valleys.

GLACIAL AND POSTGLACIAL GEOLOGIC HISTORY

The following reconstruction of the Quaternary history of the Norway quadrangle and surrounding area is based on the interpretations of surficial earth materials described in this report, together with published information from surrounding areas of New England. It is uncertain how many episodes of glaciation have affected the study area during the Pleistocene Ice Age. Till deposits in western Maine clearly record the most recent (late Wisconsinan) glaciation, and probably one earlier event. The deeply weathered lower till found elsewhere in central and southern New England has also been recognized in this part of the state (Thompson and Borns, 1985; Weddle and others, 1989). Although it is not well-dated, the lower till was deposited during the penultimate glaciation, of probable Illinoian age.

Data summarized by Stone and Borns (1986) indicate that the late Wisconsinan Laurentide Ice Sheet expanded out of Canada and spread into Maine approximately 25,000 radiocarbon years ago. As the glacier continued to flow across the state for thousands of years, it shaped the surface of the land by eroding, transporting, and depositing tremendous quantities of sediment and rock debris. The combined effects of erosion and deposition have given some hills a streamlined shape, with their long axes parallel to the south-southeastward flow of the ice. Prominent streamlining is seen on many till-covered hills in the quadrangle, particularly in the southern half of the map area (such as Andrews Hill and Allen Hill). Glacial plucking on the lee sides of some hills created steep south-facing bedrock slopes.

Abrasion by rock debris dragged at the base of the glacier polished and striated the bedrock surface. The striations are not easy to see in the Norway quadrangle because in many places they are either concealed beneath surficial sediments, or have been destroyed by weathering at the ground surface. The geologic map shows sites where striation trends have been recorded. Good examples of striations and glacially polished ledges are exposed in the vicinity of the Frost Hill municipal waste facility in Norway, and on a ledge next to Route 26 just south of Norway village.

Most striation localities indicate glacial flow toward the southeast or south-southeast. This flow presumably occurred during the maximum phase of late Wisconsinan glaciation, when the glacially streamlined hills were sculpted with the same orientation. In the few places where striations record more than one flow direction, the later flow probably was more southerly. This southward shift is believed to have resulted from reorganization

of ice flow in southwestern Maine as the glacier thinned over the Mahoosuc Range to the north (Thompson and Koteff, 1995; Thompson, in press).

The minimum age of glacial retreat from the Norway quadrangle can be estimated from radiocarbon dating of organic material in lake-bottom sediments deposited soon after deglaciation. Thompson and others (1996) obtained an age of 13,200 radiocarbon years from Cushman Pond in Lovell, located a short distance west of Norway, so the study area probably was deglaciated by this time. However, isolated masses of stagnant ice may have lingered in valleys. The nearby Saco Valley was certainly ice-free by 12,000 years ago, judging from dated plant remains in Fryeburg (Thompson, 1999).

In coastal Maine it is possible to trace the retreat of the glacier margin in detail because there are hundreds of end-moraine ridges, submarine fans, and deltas that were deposited at the edge of the ice during its recession in a marine environment. End moraines are rare in the Norway quadrangle, making it more difficult to reconstruct the pattern of deglaciation. However, a few short moraines (Pem) formed in the Greenley Brook valley and its tributaries. It is inferred from the moraines and the orientations of meltwater channels in the uplands that ice recession proceeded in a generally north to northwestward direction.

Some of the rock debris in the ice sheet was released directly from the glacier as deposits of till (unit Pt), end moraines (Pem), hummocky moraine (Phm), or ribbed moraine (Prm). Many of these deposits include large boulders, as well as variable percentages of sand and gravel resulting from the winnowing action of meltwater.

A meltwater stream system within the glacier deposited sand and gravel in a subglacial ice tunnel, forming the segmented esker (unit Pge) in the Little Androscoggin Valley. Meltwater issuing from the glacier margin deposited large quantities of sandy to gravelly sediments during deglaciation. In Oxford, a delta (unit Pmdo) built southward in the Little Androscoggin River valley, covering the marine clay deposits that were previously deposited in this area. The youngest glacial meltwater deposits in the quadrangle are the outwash units in the Crooked River and Little Androscoggin Valleys (units P goc and P gol). These deposits formed when the ice margin lay farther up the valleys, north and west of the map area.

Eolian sand dunes (unit Qe) were deposited on the east side of the Crooked River valley in late-glacial to postglacial time, and dunes probably also formed adjacent to the sand plain in the Little Androscoggin Valley. Wetlands (unit Hw) and flood plains (unit Ha) began to develop soon after deglaciation, and continue to accumulate sediments to the present day.

ECONOMIC GEOLOGY

Sand and gravel supplies are plentiful in several valleys in the Norway quadrangle. Gravel is likely to be found in the esker

system (Pge) that extends up the Little Androscoggin Valley. Much additional sand and gravel is contained in the marine delta in this valley (Pmdo), and in the outwash deposits of the Crooked River valley (P goc). Numerous pits have already been opened in these deposits. Gravel most likely occurs in the upper part of the marine delta, while sand is often abundant at depth. In the more southerly part of the Little Androscoggin Valley, the deltaic deposits are underlain by marine silt and clay. This clay is rarely exposed, but is said to have been used for making pottery (Lee Dassler, personal communication, 2000)

Many small borrow pits have been opened in glacial till deposits. The sandy till in this area packs well and is often well-suited for fill. It may also provide favorable sites for septic tank absorption fields.

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APPENDIX A

GLOSSARY OF TERMS USED ON MAINE GEOLOGICAL SURVEY SURFICIAL GEOLOGIC MAPS

*compiled by
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Note: Terms shown in italics are defined elsewhere in the glossary.

Ablation till: *till* formed by release of sedimentary debris from melting glacial ice, accompanied by variable amounts of slumping and meltwater action. May be loose and stony, and contains lenses of washed sand and gravel.

Basal melt-out till: *till* resulting from melting of debris-rich ice in the bottom part of a glacier. Generally shows crude stratification due to included sand and gravel lenses.

Clast: pebble-, cobble-, or boulder-size fragment of rock or other material in a finer-grained *matrix*. Often refers to stones in glacial till or gravel.

Clast-supported: refers to sediment that consists mostly or entirely of *clasts*, generally with more than 40% clasts. Usually the clasts are in contact with each other. For example, a well-sorted cobble gravel.

Delta: a body of sand and gravel deposited where a stream enters a lake or ocean and drops its sediment load. Glacially deposited deltas in Maine usually consist of two parts: (1) coarse, horizontal, often gravelly topset beds deposited in stream channels on the flat delta top, and (2) underlying, finer-grained, inclined foreset beds deposited on the advancing delta front.

Deposit: general term for any accumulation of sediment, rocks, or other earth materials.

Diamicton: any poorly-sorted sediment containing a wide range of particle sizes, e.g. glacial *till*.

Drumlin: an elongate oval-shaped hill, often composed of glacial sediments, that has been shaped by the flow of glacial ice, such that its long axis is parallel to the direction of ice flow.

End moraine: a ridge of sediment deposited at the margin of a glacier. Usually consists of till and/or sand and gravel in various proportions.

Englacial: occurring or formed within glacial ice.

Eolian: formed by wind action, such as a sand dune.

Esker: a ridge of sand and gravel deposited at least partly by meltwater flowing in a tunnel within or beneath glacial ice. Many ridges mapped as eskers include variable amounts of sediment deposited in narrow open channels or at the mouths of ice tunnels.

Fluvial: Formed by running water, for example by meltwater streams discharging from a glacier.

Glaciolacustrine: refers to sediments or processes involving a lake which received meltwater from glacial ice.

Glaciomarine: refers to sediments and processes related to environments where marine water and glacial ice were in contact.

Head of outwash: same as *outwash head*.

Holocene: term for the time period from 10,000 years ago to the present. It is often used synonymously with “postglacial” because most of New England has been free of glacial ice since that time.

Ice age: see *Pleistocene*.

Ice-contact: refers to any sedimentary deposit or other feature that formed adjacent to glacial ice. Many such deposits show irregular topography due to melting of the ice against which they were laid down, and resulting collapse.

Kettle: a depression on the ground surface, ranging in outline from circular to very irregular, left by the melting of a mass of glacial ice that had been surrounded by glacial sediments. Many kettles now contain ponds or wetlands.

Kettle hole: same as *kettle*.

Lacustrine: pertaining to a lake.

Late-glacial: refers to the time when the most recent glacial ice sheet was receding from Maine, approximately 15,000-10,000 years ago.

Late Wisconsinan: the most recent part of *Pleistocene* time, during which the latest continental ice sheet covered all or portions of New England (approx. 25,000-10,000 years ago).

Lodgement till: very dense variety of till, deposited beneath flowing glacial ice. May be known locally as “hardpan.”

Matrix: the fine-grained material, generally silt and sand, which comprises the bulk of many sediments and may contain *clasts*.

Matrix-supported: refers to any sediment that consists mostly or entirely of a fine-grained component such as silt or sand. Generally contains less than 20-30% clasts, which are not in contact with one another. For example, a fine sand with scattered pebbles.

Moraine: General term for glacially deposited sediment, but often used as short form of “*end moraine*.”

Morphosequence: a group of water-laid glacial deposits (often consisting of sand and gravel) that were deposited more-or-less at the same time by meltwater streams issuing from a particular position of a glacier margin. The depositional pattern of each morphosequence was usually controlled by a local base level, such as a lake level, to which the sediments were transported.

Outwash: sediment derived from melting glacial ice and deposited by meltwater streams in front of a glacier.

Outwash head: the end of an *outwash* deposit that was closest to the glacier margin from which it originated. *Ice-contact* outwash heads typically show steep slopes, *kettles* and hummocks, and/or boulders dumped off the ice. These features help define former positions of a retreating glacier margin, especially where *end moraines* are absent.

Pleistocene: term for the time period between 2-3 million years ago and 10,000 years ago, during which there were several glaciations. Also called the “Ice Age.”

Proglacial: occurring or formed in front of a glacier.

Quaternary: term for the era between 2-3 million years ago and the present. Includes both the *Pleistocene* and *Holocene*.

Striation: a narrow scratch on bedrock or a stone, produced by the abrasive action of debris-laden glacial ice. Plural form sometimes given as “*striae*.”

Subaqueous fan: a somewhat fan-shaped deposit of sand and gravel that was formed by meltwater streams entering a lake or ocean at the margin of a glacier. Similar to a *delta*, but was not built up to the water surface.

Subglacial: occurring or formed beneath a glacier.

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Till: a heterogeneous, usually non-stratified sediment deposited directly from glacial ice. Particle size may range from clay through silt, sand, and gravel to large boulders.

Topset/foreset contact: the more-or-less horizontal boundary between topset and foreset beds in a *delta*. This boundary closely approximates the water level of the lake or ocean into which the delta was built.